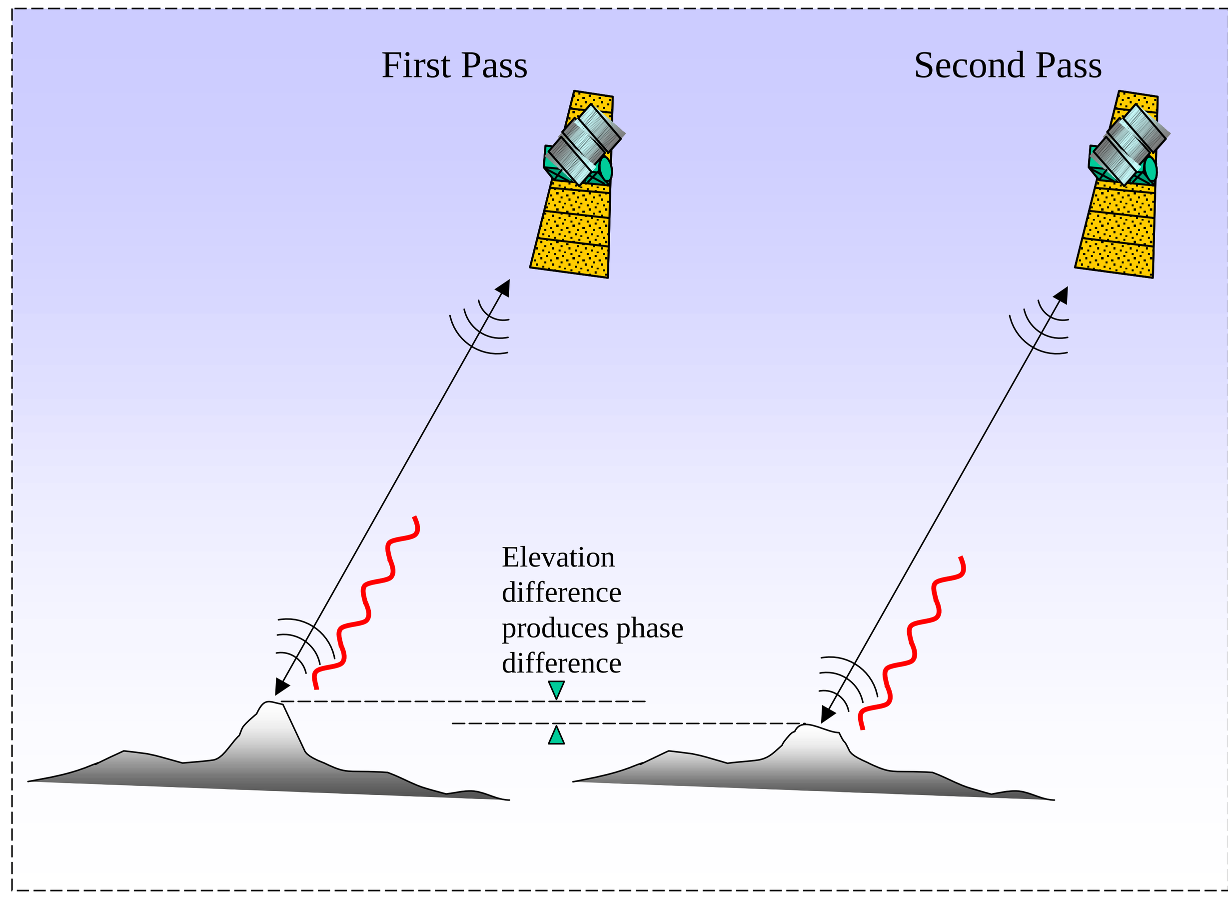
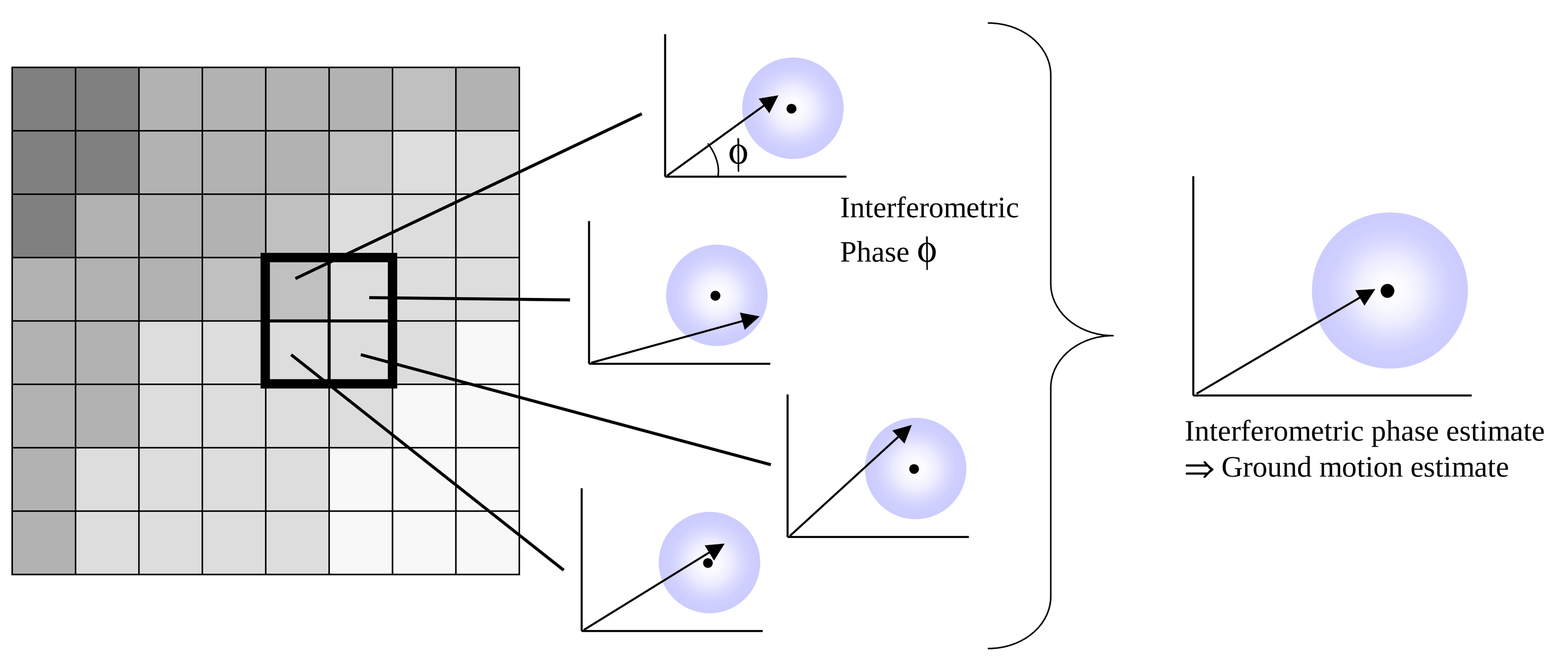
Coherent Target Monitoring: basic theory and initial results

In *conventional* differential SAR interferomentry (DIFSAR), the SAR satellite collects data over the same region at two different times. Elevation changes on the surface create phase changes in the received signal and ground motion may be inferred.



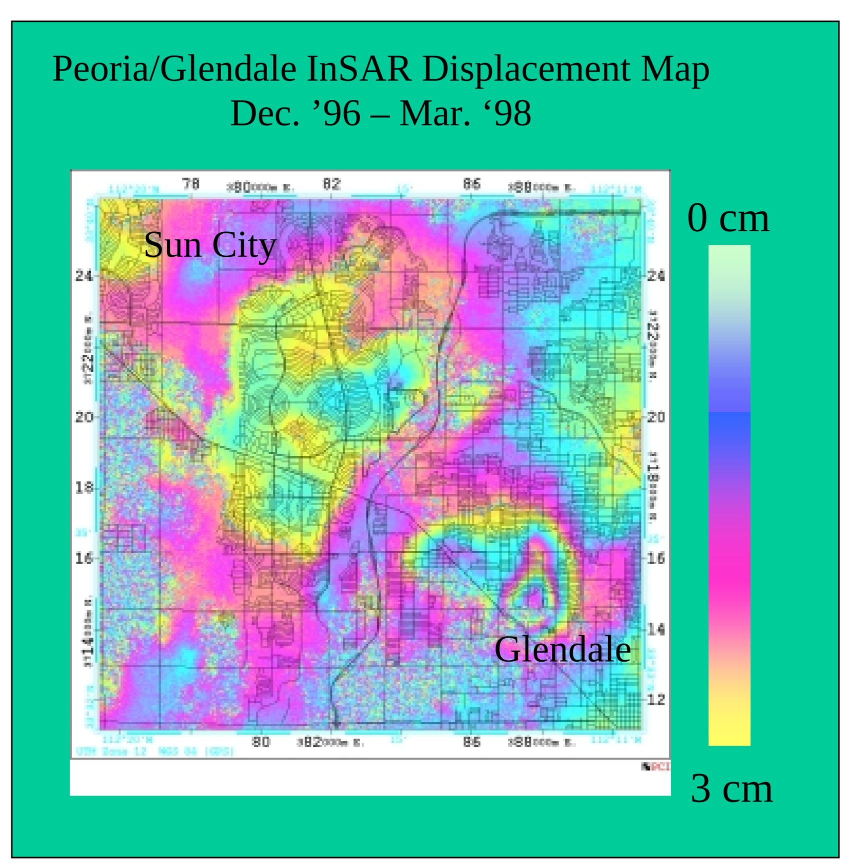
Displacement is encoded in the SAR phase measurement at each point (pixel). Since the measured phase is inherently a noisy quantity, several neighboring pixels must be averaged to obtain a good local phase estimate.



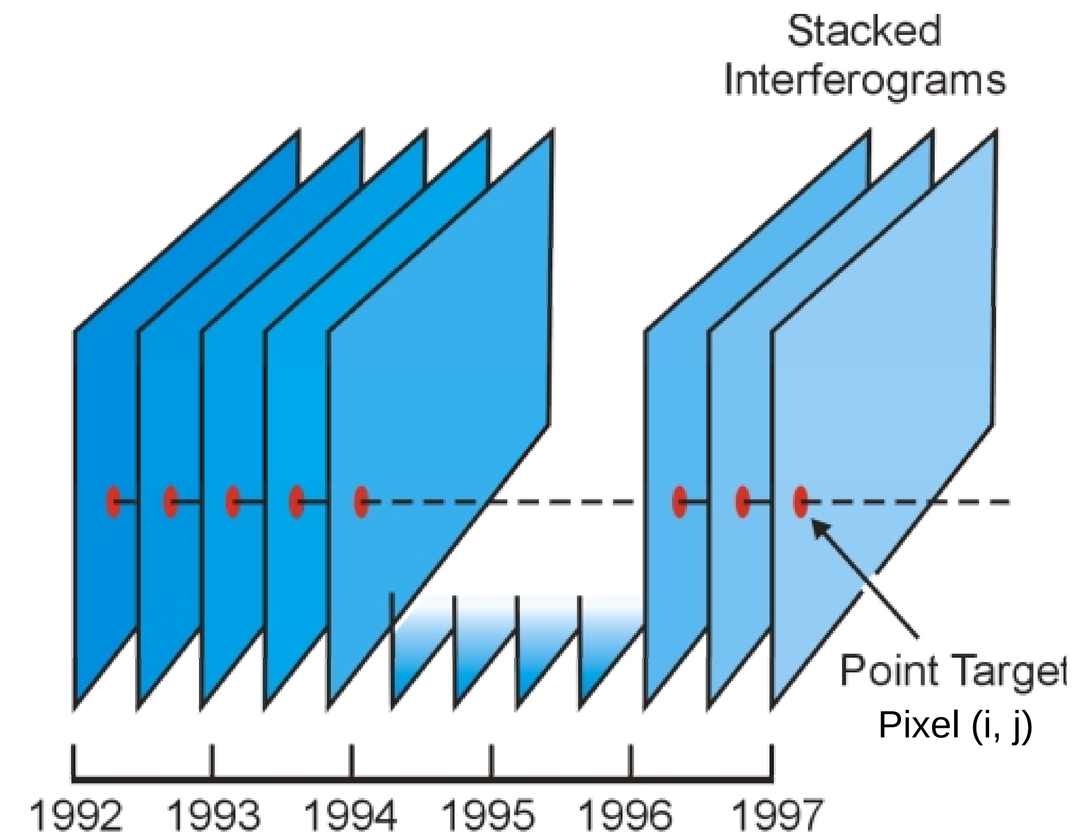
Conventional DIFSAR has had great success under good conditions. There are three drawbacks:

1. Resolution is lost when pixels are averaged for the phase estimate.
2. Since pixel averaging is required for phase estimate, poor quality pixels (low signal) can corrupt the phase estimate (and, therefore, the displacement estimate.)
3. Atmospheric moisture can cause phase delays that are indistinguishable from surface displacements

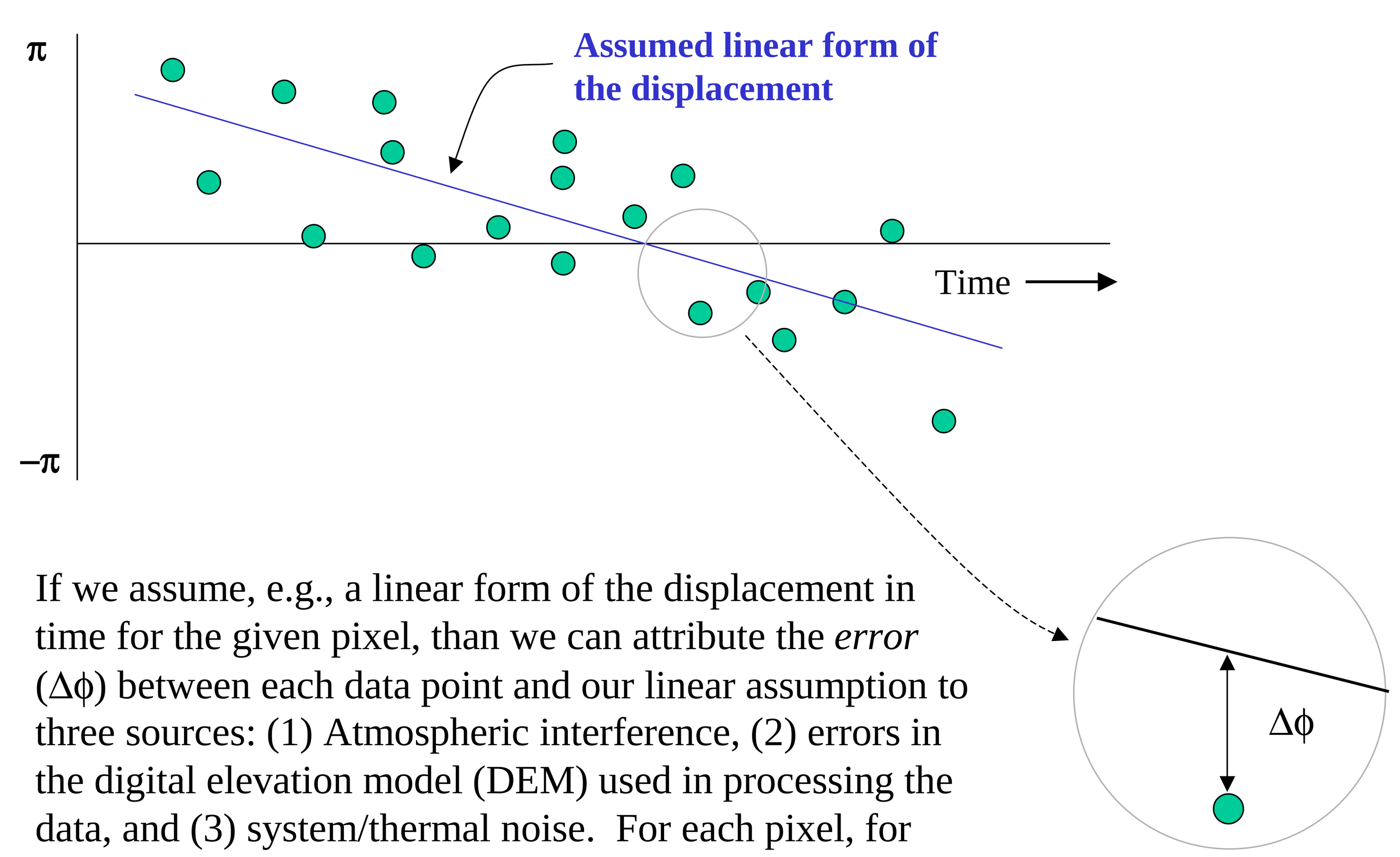
An emerging processing approach called Coherent Target Monitoring (CTM) can mitigate the problems with conventional interferometry.



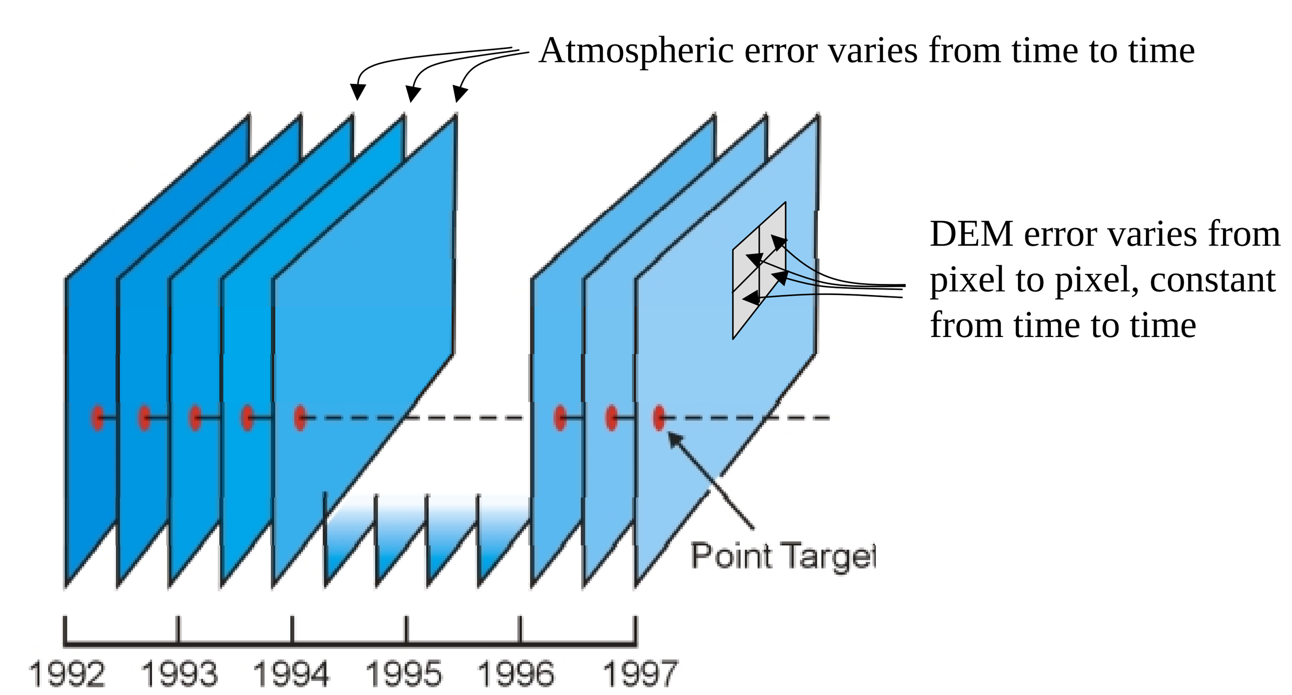
CTM uses a time series of SAR data. Instead of estimating phase by averaging over several pixels, CTM estimates phase by averaging over time for each pixel.



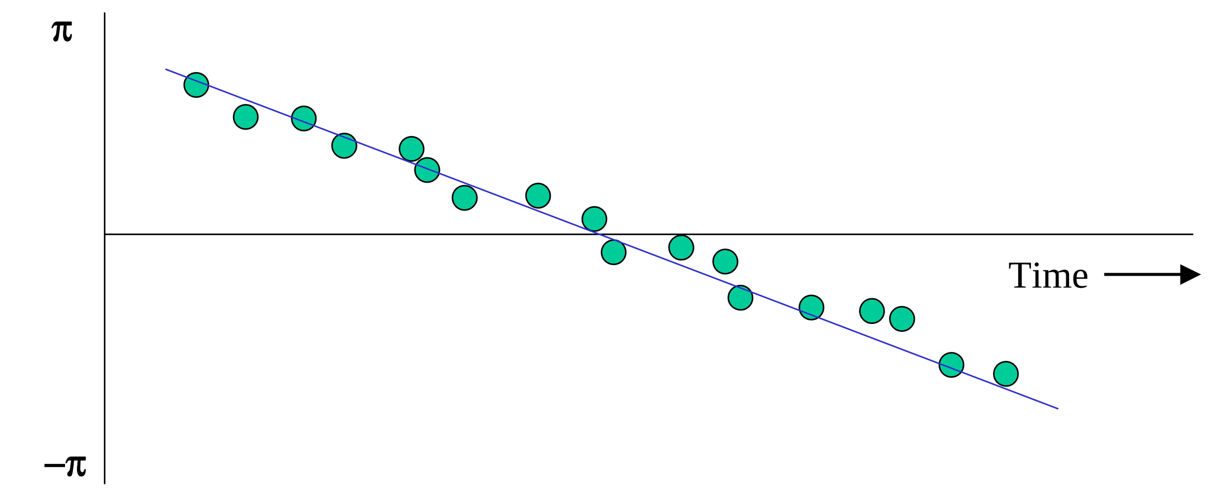
The technique requires a radar return for a given pixel that is stable over the time series where *stable* denotes its scattering stability, not its motion. A corner reflector is an example of a good stable scatterer. Once some normalization has been done, the phase signal from from a given pixel containing a slowly moving scatterer (e.g., due to ground subsidence) would look like:

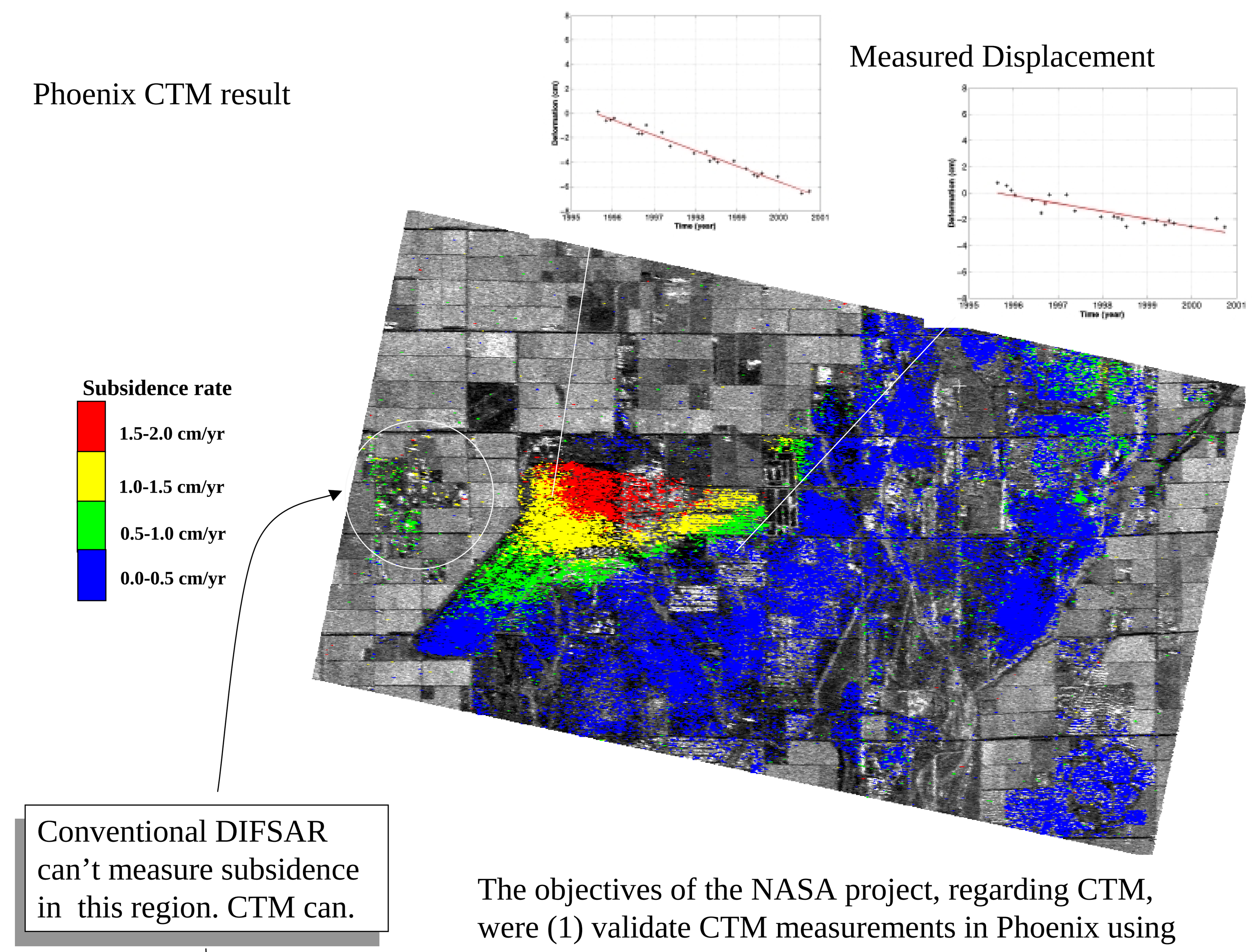


If we assume, e.g., a linear form of the displacement in time for the given pixel, than we can attribute the *error* (Δϕ) between each data point and our linear assumption to three sources: (1) Atmospheric interference, (2) errors in the digital elevation model (DEM) used in processing the data, and (3) system/thermal noise. For each pixel, for each time, we can iteratively estimate and remove the atmospheric and DEM errors.



For a stable scatterer, once errors have been removed, the data phase fit the assumed functional form. NOTE: phase estimates are now summed along time axis – the analogue of the spatial phase estimate in conventional interferometry.





The objectives of the NASA project, regarding CTM, were (1) validate CTM measurements in Phoenix using conventional interferometry, and (2) attempt to make interferometric measurements in an area where conventional DIFSAR fails. We have limited validation of the first and have achieved the second.